REGISTER ENTRY FOR SG PUBLICATION NO: 140512

Application No.:	200606050-3	**Filing date:**	04/Sep/2006
Title of Invention:	ELECTRICAL CURRENT DISTRIBUTION IN LIGHT EMITTING DEVICES		
Applicant/Proprietor(s):	TINGGI TECHNOLOGIES PRIVATE LIMITED (SG) 83 SCIENCE PARK DRIVE #03-01 SINGAPORE 118258 SINGAPORE		
Inventor(s):	YUAN SHU C/O TINGGI TECHNOLOGIES PRIVATE LIMITED 83 SCIENCE PARK DRIVE, #03-01, SINGAPORE 118258 SINGAPORE LIN SHI MING C/O TINGGI TECHNOLOGIES PRIVATE LIMITED 83 SCIENCE PARK DRIVE, #03-01, SINGAPORE 118258 SINGAPORE		
International Patent Classification:	H01L 33/00, H01L 23/482		
Patent Agent:	LLOYD WISE P.O. BOX 636 TANJONG PAGAR POST OFFICE SINGAPORE 910816		
Address for service:	P.O. BOX 636 TANJONG PAGAR POST OFFICE SINGAPORE 910816		
Date of Abstract Publication:	28/Mar/2008	**SG Publication No.:**	140512
Date of grant of patent:	31/Mar/2009		

Other Entries:

Date	Event
11/Sep/2006	FE CLEAR REPORT ISSUED

05/Oct/2006	NOTIFICATION OF CHANGE OF APPLICATION PATENT AGENT, FROM LLOYD WISE, P.O. BOX 636, TANJONG PAGAR POST OFFICE, SINGAPORE 910816 TO LLOYD WISE, P.O. BOX 636, TANJONG PAGAR POST OFFICE, SINGAPORE 910816
30/Oct/2006	BIBLIOGRAPHIC PUBLICATION OF APPLICATION FILED
28/Mar/2008	ABSTRACT PUBLICATION OF APPLICATION
03/Dec/2008	PRESCRIBED INFORMATION FILED
09/Dec/2008	APPLICATION FOR AMENDMENT OF SPECIFICATION ACCEPTED BY THE REGISTRAR
31/Mar/2009	PATENT GRANTED WITH EFFECT FROM 31/Mar/2009
30/Apr/2009	PUBLICATION OF GRANT

RENEWAL DETAILS

SG PUBLICATION NUMBER:	140512
APPLICATION NUMBER:	200606050-3
PROPRIETOR(S):	TINGGI TECHNOLOGIES PRIVATE LIMITED (SG)
FILING DATE:	04/Sep/2006
GRANT DATE:	31/Mar/2009
DATE NEXT RENEWAL DUE:	04/09/2010
YEAR OF LAST RENEWAL:	0
STATUS:	PATENT IN FORCE

Electrical Current Distribution in Light Emitting Devices

Field of the Invention

This invention relates to electrical current distribution in light emitting devices and refers particularly, through not exclusively, to apparatus for spreading the electrical current so as to maximize light output.

Reference to Related Application

Reference is made to our earlier Singapore patent application 20506301-1 filed 29 September 2005, the contents of which are incorporated herein by reference as if disclosed herein in their entirely.

Backgroud of the Invention

In most light emitting devices such as for example, light emitting diodes and laser diodes, bonding pads occupy about 15% of the surface area of the light emitting surface. Where the bonding pad is located, light cannot be emitted.

Also, as the electrical current flows from the bonding pad to the active region and will follow the path of least resistance (normally the shortest path, in uniform materials) the maximum current flow, and thus maximum light output, is beneath the bonding pad. This results in a significant reduction in the light output.

Summary of the Invention

In accordance with a first preferred aspect there is provided a light emitting device comprising a plurality of epitaxial layers including an active layer; at least one of a reflective layer and an ohmic contact on a first side of the epitaxial layers; and a layer of a conductive metal on a second side of the epitaxial layers and having a light emitting

surface. A terminal is on the light emitting surface. The terminal has an array for diffusing electrical current and minimizing its effect on light output.

The array may comprise a bonding pad, an outer portion, and a joining portion connecting the bonding pad and the outer portion; the outer portion and the joining portion being for current dissipation. The outer portion may be at or adjacent a periphery of the light emitting surface. The joining portion may comprise a plurality of spokes joining the bonding pad and the outer portion.

There may be a second reflective layer between the array and the light emitting surface. Alternatively, the second reflective layer may be at a bottom of a trench in the light emitting surface.

In accordance with a second preferred aspect there is provided a method of fabricating a light emitting device. The light emitting device has a plurality of epitaxial layers including an active layer, a reflective layer on a first side of the epitaxial layers, and a conductive metal on a second side of the epitaxial layers. The method includes forming a terminal on a light emitting surface of the conductive metal, the terminal having an array for diffusing electrical current and minimizing its effect on light output.

The forming of the array may be by forming a bonding pad, an outer portion, and a joining portion electrically connecting the bonding pad and the outer portion; the outer portion and the joining portion being for current dissipation. The outer portion may be at or adjacent a periphery of the light emitting surface. The joining portion may comprise a plurality of spokes joining the bonding pad and the outer portion.

The method may further comprise forming second reflective layer on the light emitting surface before forming the array on the second reflective layer.

Alternatively, the method may further comprise forming trench in the light emitting surface, forming a second reflective layer at a bottom of the trench, the array being formed on the second reflective layer.

Brief Description of the Drawings

In order that the present invention may be fully understood and readily put into practical effect, there shall now be described by way of non-limitative example only preferred embodiments of the present invention, the description being with reference to the accompanying illustrative drawings.

In the drawings:

Figure 1 is a schematic side view of a light emitting device;
Figure 2 is a schematic side view of a preferred embodiment of a light emitting device;
Figure 3 is a stop pan view of the device of Figure 2;
Figure 4 is a vertical cross-section along the lines and in the direction of arrows 4-4 on Figure 3; and
Figure 5 is an enlarged view of the trench of Figure 4;
Figure 6 is an alternative to the arrangement of Figure 5;
Figure 7 to 13 are series of views corresponding to Figure 4 showing the fabrication of the device of Figures 2 to 4.

Detailed Description of the Preferred Embodiments

To first refer to Figure 1 there is shown a light emitting device 101 such as, for example, a light emitting diode or a laser diode, and having a reflective layer and/or ohmic contact 103 on a first side of a plurality of epitaxial layers including an active region 102. A conductive metal layer 104 is on a second side of the epitaxial layers. The reflective layer 103 may be on the epitaxial layers and the ohmic contact on the reflective layer, or vice versa. There may be only one of them. A bonding pad 105 is provided on the light output surface 107. The electrical current flows in the metal layer 104 to the active layer 102 by the paths as shown with the dotted lines on Figure 1. As can be seen, the maximum electrical current is concentrated under the bond pad 105. That means the maximum light emitted by the active layer 102 (as shown by the sold

lines) will also be concentrated under the bonding pad 105. Such light will be reflected back into layer 104 by the bonding pad 105. This significantly reduces the light output.

Figure 2 to 4 show a preferred embodiment where like reference numerals are used for like components but the prefix number "1" is changed to "2". Here, the bonding pad 105 is replaced by a terminal layer 215.

The terminal layer 215 comprises an array 214 of electrically conductive material, preferably the same material as the bonding pad 205, and which is electrically connected to both the bonding pad 205 and the light output surface 207. The array 214 is distributed over the surface 207 so that electrical current will flow from the terminal layer 215 to the active region 202 in a diffused or distributed manner.

The array 214 preferably has the bonding pad 205 as its center so the distribution of the array 214 is relatively uniform over the surface 207. Also, it is preferred for the array 214 to be of reduced height when compared with the bonding pad 205.

As shown, the array 214 comprises an outer portion 206 that is at or adjacent the periphery of surface 207. This is to provide for light emission from at, and adjacent to, the periphery of active region 202. Electrically and physically connecting the outer portion 206 and the bonding pad 205 is a joining portion 208 that is, in this case, four equally-spaced radial "spokes" extending from the bonding pad 205 to the outer portion 206. All spokes 208 are preferably identical, and are more preferably of the same height and width as the outer portion 206. Although four spokes 208 are shown in a cruciform shape, there may be any suitable number of spokes such as, for example, one, two, three, four, five, six, and so forth.

Between the spokes 208 and the outer portion 206 are light-emitting openings 209 for emission of light from light output surface 207.

The outer portion 206 and/or each spoke 208 or array 214 may be located in a trench 211 formed in the light output surface 207. The trench 211 may have a reflective layer

212 at its bottom 213 so that light propagated by active region 202 under the array 214 will be more efficiently reflected by reflective layer 212. The reflective layer 212 may have a diffusing surface so that light will be reflected from it an angle other than perpendicular. The reflective layer 212 is electrically conductive to enable electric current to pass from array 214 to the active region 202. The reflecting layer 212 is preferably of the same shape and dimensions on surface 207 as the array 214.

As shown in Figure 6, the trench 211 may not be used and the reflective layer 212 may be applied directly to the light output surface 207 beneath array 214.

Figure 7 to 13 show the process. These are Figures 11 to 17 of the related application, and are the process step after the original sapphire substrate 4 is removed.

As shown in Figure 8, after removal of the sapphire substrate 4, the devices are isolated from each other by trench etching from the newly exposed surface 13 along the edges of the mesa, as shown in Figure 8 to 10, with a photoresist layer 6(d) protecting the regions of the n-type GaN layer 3 during the etching process.

Alternatively, the lowermost surface 13 of the n-type layer 3 may be cleaved at locations in alignment with the photoresists 12 and the dies separated. This is of advantage for laser diodes as the exposed side surfaces of the n-type layer 3 are substantially parallel, thus causing a large amount of total internal reflection. This acts as a light amplification system for improved, and directed light, output.

Pad etching takes place after applying a fifth resist layer 6(e) over the exposed surfaces of SiO_2 layer 8, the sides of the n-type GaN layer 3, and the center of the n-type GaN layer 3 [Figure 9(a) and (b)] thus forming projecting portions 14 and recess portions 15 of n-type GaN layer 3.

The resist 6(e) is the removed and a further resist 6(f) applied over the exposed surfaces of the n-type GaN layer 3 and the outer periphery of the SiO_2 layer 8 to thus leave a gap 16 for die isolation. Etching takes place (Figure 10) through the gap 16 and the SiO_2

layer 8, and seed layer 11 until the ends of the thick photoresists 12 are exposed. The resist 6(f) is removed.

A final resist layer 6(g) is applied over all exposed lower-surfaces from the edge of the SiO_2 layer 8 through to adjacent the center of the n-type GaN layer 3, where a central gap 17 remains (Figure 11).

An array 214 of layer or layers 18 of n-type metals are then applied over the resist 6(g) with the layer 18 at the gap 17 at the center of the n-type GaN layer 3 being applied directly to the GaN layer 3 (Figure 12). The resist layer 6(g) with the layer 18 attached, is removed leaving the layer 18 attached to the center 17 of the n-type GaN layer 3 where gap 17 was previously located.

In this way the seed layers 11, 10, 9 and the copper layer 9(a) act as reflectors to increase light output, with copper layer 9(a) being one terminal, thus not interfering with light output. The second terminal is layer 18 in array 214 on the n-type layer 3 of GaN and this is an array at and/or around the center of that layer 3, thus minimizing its effect on light output, and increasing the diffusion of current.

Whilst there has been described in the foregoing description preferred embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made without departing from the present invention.

THE CLAIMS

1. A light emitting device comprising:
   (a) a plurality of epitaxial layers including an active layer;
   (b) a reflective layer on a first side of the epitaxial layers;
   (c) a layer of a conductive metal on a second side of the epitaxial layers and having a light emitting surface;
   (d) a terminal comprising an array on the light emitting surface, the array being for diffusing electrical current and minimizing its effect on light output; and
   (e) a second reflective layer beneath the array on the light emitting surface or at a bottom of a trench in the light emitting surface, the second reflective layer being for reflecting light propagated by the active layer under the array and being electrically conductive to enable electric current to pass from the array to the active layer.

2. A light emitting device as claimed in claim 1, wherein the array comprises a bonding pad, an outer portion, and a joining portion connecting the bonding pad and the outer portion; the outer portion and the joining portion being for current dissipation.

3. A light emitting device as claimed in claim 2, wherein the outer portion is at or adjacent a periphery of the light emitting surface.

4. A light emitting device as claimed in claim 2 or claim 3, wherein the joining portion comprises a plurality of spokes joining the bonding pad and the outer portion.

5. A method of fabricating a light emitting device comprising a plurality of epitaxial layers including an active layer, a reflective layer on a first side of the epitaxial layers and a conductive metal on a second side of the epitaxial layer, the conductive metal having a light emitting surface; the method comprising:

forming a second reflective layer on the light emitting surface or at a bottom of a trench in the light emitting surface; and

forming a terminal comprising an array on the second reflective layer, the array being for diffusing electrical current and minimizing its effect on light output;

the second reflective layer being for reflecting light propagated by the active layer under the array and being electrically conductive to enable electric current to pass from the array to the active layer.

6. A method as claimed in claim 5, wherein the forming of the array is by forming a bonding pad, an outer portion, and a joining portion electrically connecting the bonding pad and the outer portion; the outer portion and the joining portion being for current dissipation.

7. A method as claimed in claim 6 wherein the outer portion is at or adjacent a periphery of the light emitting surface.

8. A method as claimed in claim 6 or claim 7, wherein the joining portion comprises a plurality of spokes joining the bonding pad and the outer portion.

ABSTRACT

Electrical Current Distribution in Light Emitting Devices

A light emitting device is disclosed that has a plurality of epitaxial layers including an active layer; at least one of a reflective layer and an ohmic contact on a first side of the epitaxial layers; and a layer of a conductive metal on a second side of the epitaxial layers and having a light emitting surface. A terminal is on the light emitting surface, the terminal comprising an array for diffusing electrical current and minimizing its effect on light output. The array may have a bonding pad, an outer portion, and a joining portion connecting the bonding pad and the outer portion; the outer portion and the joining portion being for current dissipation.

Figure 2

162162

G00002

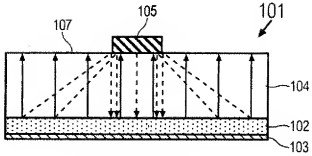

FIGURE 1

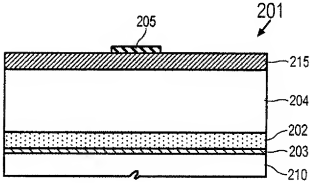

FIGURE 2

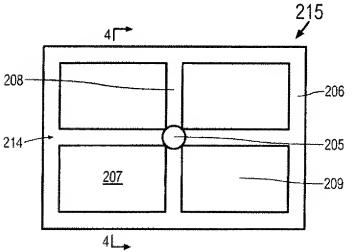

FIGURE 3

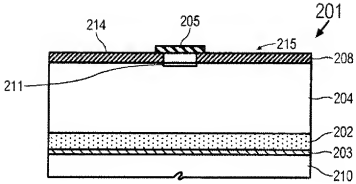

FIGURE 4

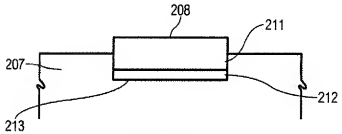

FIGURE 5

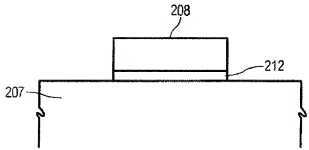

FIGURE 6

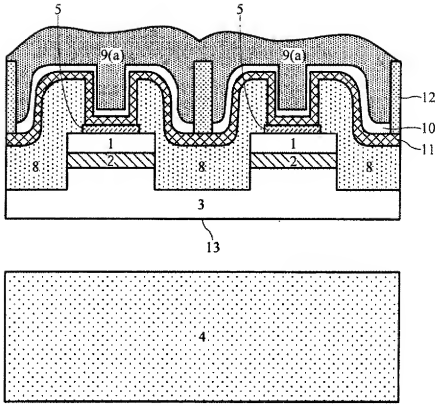

FIGURE 7

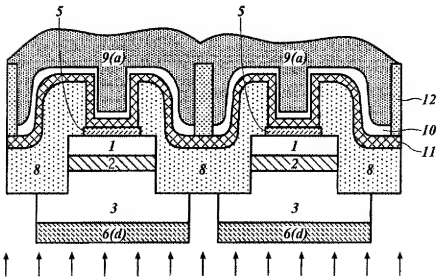

FIGURE 8

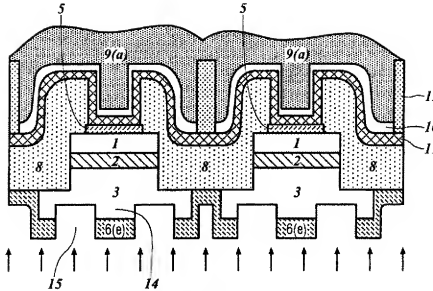

FIGURE 9A

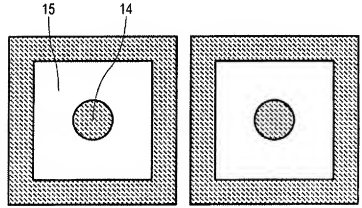

FIGURE 9B

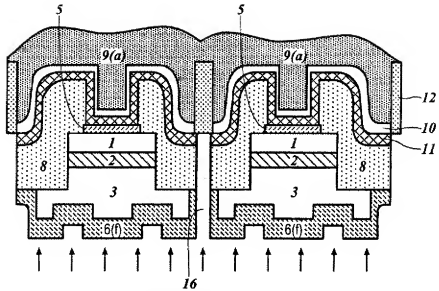

FIGURE 10A

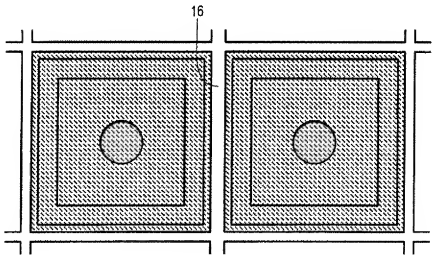

FIGURE 10B

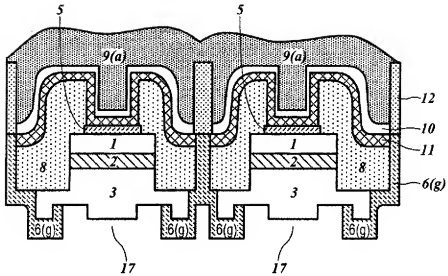

FIGURE 11A

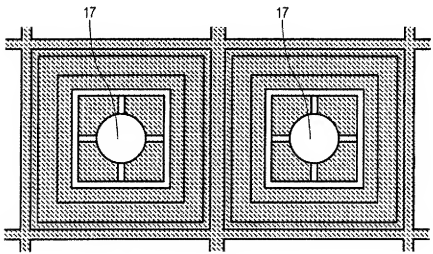

FIGURE 11B

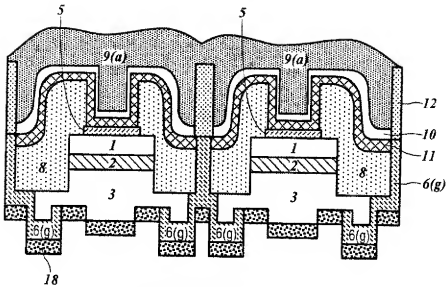

FIGURE 12

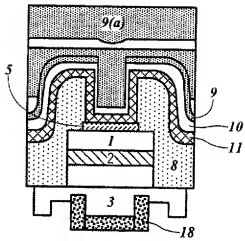

FIGURE 13A

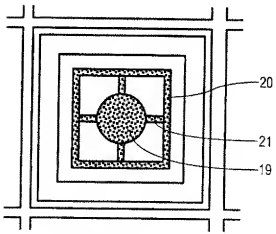

FIGURE 13B